bodies, pedicles, vertebral arches (including facet joints and pars interarticularis areas), or disc spaces. Such information results in accurately detecting and localizing fractures (differentiating vertebral body, pedicle, facet, and pars interarticularis locations), infections (including discitis), neoplasms (ranging from malignant tumors in vertebral bodies and pedicles to osteoid osteomas in lamina sites), and joint disease (distinguishing between articular facets and disc space-oriented abnormalities). The origin of pelvic pain can be localized to sacroiliac joints or hips, and for the hips, SPECT can discriminate between degenerative joint disease, avascular necrosis, tumors, inflammation, or fractures.

Bone imaging of many sites using SPECT is superior to conventional bone scanning. A normal-appearing conventional bone scan may harbor a lesion uncovered by SPECT. This tomographic technique improves diagnostic accuracy and also results in more meaningful consultations with referring physicians and diagnostic radiologists. The cost of a bone scan is generally less than that of a CT scan, but more than standard radiographs. Bone scanning using SPECT is superior to conventional radiography, and some investigators report more abnormalities shown by SPECT in patients with chronic low back pain than by CT.

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Positron Emission Tomographic Oncology

COMPUTED TOMOGRAPHY (CT) and magnetic resonance imaging (MRI) are elegant structural—that is, anatomical—imaging methods that have been used extensively in the diagnosis and staging of neoplasms and in follow-up after initial specific therapies, particularly in the posttherapy evaluation of suspected residual or recurrent neoplasm. Structural characteristics, however, are not sufficient to determine malignancy or to assess the distribution and extent of metabolically active tumor(s). Positron emission tomography (PET) is now showing its value as an imaging modality to identify the presence, extent, distribution, and metabolic character of a wide variety of neoplasms. Positron-emitting radiotracers have been synthesized and used to probe perfusion, oxygen metabolism, glucose metabolism, protein synthesis, nucleic acid metabolism, receptor concentrations, and tissue ischemia.

Of these agents, fludeoxyglucose F 18 (^{18}FDG) has become the most used PET radiotracer in both research and clinical applications. The active uptake and concentration of ^{18}FDG in neoplasms provides the positive signal for tumor identification in special scanning systems (PET scanners) capable of detecting photons from the decay of the ^{18}F isotope.

Researchers at the National Institutes of Health have shown that the amount of ^{18}FDG uptake in brain tumors is more predictive of prognosis than tumor grade or location. Initially low-grade tumors may undergo malignant degeneration that can be detected by PET, and following therapy, PET can identify sites of recurrence and distinguish these from regions of necrosis and fibrosis. Positron emission tomography is frequently used to guide biopsy studies toward the most metabolically active regions of tumors.

Head and neck tumors that are initially fairly well defined by CT and MRI may be associated with contralateral disease and ipsilateral lymph nodes smaller than 1 cm; PET can determine which of these is metabolically active. These tumors frequently recur following initial surgical therapy and subsequent radiotherapy, which produce distortions in local tissues when assessed by CT and MRI. When tumors recur, the PET signal may not be affected by the preceding treatments.

Lung cancers have been accurately diagnosed and staged with PET, which according to published reports has sensitivities and specificities in excess of 90% for diagnosing solitary pulmonary nodules and staging the mediastinum. Published data suggest that CT has limited sensitivity and specificity for diagnosing and staging lung cancers. If used in the initial evaluation of solitary pulmonary nodules, PET may reduce the number of thoracotomies that are being done for benign solitary pulmonary nodules as well as complications associated with transthoracic needle biopsies and thoracotomies. A prospective multi-institutional study of solitary pulmonary nodules will be completed before the end of 1994. Similar efforts are under way with breast and colorectal cancers. A recently published study on a series of patients with ovarian carcinoma reported that PET has greater positive and negative predictive values than CT for diagnosing pelvic malignant neoplasms. But when PET and CT results are combined, the negative predictive value approaches 100%. This would be valuable in avoiding second-look operations.

Other settings where PET has proved useful are in evaluating the site and extent of residual or recurrent thyroid cancer, distinguishing carcinoma of the pancreas from chronic pancreatitis and bone metastasis from benign bone fractures, and identifying malignant transformation in initially benign lesions. Whole-body PET scans can frequently locate an occult primary while assessing the extent of associated metastases. Some infections, however, can produce a positive ^{18}FDG uptake and therefore could lead to false-positive results.

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Monoclonal Antibody Imaging of Colorectal and Ovarian Cancer

A MONOCLONAL ANTIBODY labeled with indium 111, satumomab pendetide (OncoScint CR/OV), was recently approved by the United States Food and Drug Administration and now is routinely available for the imaging of colorectal and recurrent ovarian cancers. The radiopharmaceutical is given intravenously, and imaging is done within three to five days.

OncoScint CR/OV is more sensitive than computed tomography (CT) for the detection of cancer in the pelvis (OncoScint CR/OV 74%, CT 57%), mesentery, and retroperitoneum (OncoScint CR/OV 66%, CT 34%), but less sensitive in the liver (41% versus 84%). It can detect metastatic disease in normal-sized lymph nodes and can distinguish between scar tissue and recurrent cancer. The positive predictive value of OncoScint CR/OV is 97% for colorectal cancer and 83% for recurrent ovarian cancer. Consequently, a focus of uptake usually indicates disease. The negative predictive value, however, is only 19% and 29%, respectively, so a normal scan does not rule out recurrent disease.

When used appropriately, OncoScint CR/OV can be both clinically efficacious and cost-effective. Its use can cause a false-positive elevation in carcinoembryonic antigen levels for several months, however. The $2,000 evaluation can help avoid even higher costs and influence patient management in the following four clinical settings:

- Patients with a previous history of colorectal or ovarian cancer who present with an elevated carcinoembryonic antigen or CA 125 level are at high risk for recurrent disease. In this setting CT, magnetic resonance imaging, and ultrasonography show low sensitivity and specificity. OncoScint CR/OV may identify the site of recurrence and enable earlier surgical intervention.
- Patients with "resectable" recurrence of colorectal cancer (such as a solitary liver metastasis) may be candidates for surgical resection with curative intent. If OncoScint CR/OV imaging before surgical therapy identifies unexpected nonresectable disease elsewhere, a futile operation may be avoided.
- Following resection and chemotherapy, cases of ovarian cancer are often restaged surgically because of a lack of an accurate imaging procedure for detecting residual disease. In these patients, abnormal uptake on OncoScint CR/OV imaging may make a second-look laparotomy unnecessary, or the scan can be used to direct a limited laparoscopic procedure for tissue confirmation. Because of its poor negative predictive value, however, a normal OncoScint CR/OV scan does not eliminate the need for laparotomy.
- In patients with suspected recurrence following surgical or radiation therapy for rectal cancer, CT and magnetic resonance imaging are often unable to distinguish between scar tissue and recurrent disease. OncoScint CR/OV imaging in these patients is often definitive, and the scan findings may be used to determine if palliative or possibly curative therapy is warranted.

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Regional Cerebral Blood Flow and Cocaine Abuse

COCAINE ABUSE is a major and costly problem. Single-photon emission computed tomography (SPECT) and positron emission tomography (PET) are windows into brain function. In the past decade, they have provided information about the acute and chronic effects of cocaine abuse. An aim of diagnostic imaging is to distinguish typical changes of cocaine abuse from those of other conditions. Identifying the presence of cocaine abuse will permit appropriate treatment.

Cerebral blood flow and metabolism in patients who abuse cocaine vary with the duration of withdrawal. Within a day of their last ingestion, these patients have lower than normal flow to anterior cortical areas on PET scans using oxygen 15. After seven to ten days, blood flow to the left dorsolateral prefrontal cortex continues to be decreased in most of these patients. In contrast, global brain metabolism is above normal in these patients after a week off cocaine, with regional increases in the basal ganglia and orbitofrontal cortex. The dorsolateral prefrontal cortex directs executive brain function, whereas the orbital cortex is associated with compulsive behaviors. Both receive dopaminergic innervation from the ventral tegmental area. Longer intervals off cocaine produce minimal additional changes, with persistent cerebral blood flow decreases in the dorsolateral frontal cortex on both sides and in the right parietal cortex. In a sagittal projection, blood flow deficits produce a scalloped pattern in the frontal and parietal lobes. After as long as six months of abstinence, the metabolic and cerebral blood flow deficits failed to reduce, suggesting that cocaine-induced changes are long term and may be permanent. We have recently compared 15 nonpsychotic persons with cocaine abuse with 13 control subjects using technetium Tc 99m exametazime (hexamethyl-propyleneamine oxime). Patients were drug-free for an average of 12 days before the study. In agreement with other studies, we found that those who abuse cocaine